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DOCUMENT-IDENTIFIER: US 6411359 B1
TITLE: Liquid crystal display device having smaller frame area

Abstract Text (1):
A frame area of a liquid crystal display device is reduced by improving the layouts of extraction lines DTM of drain wiring of a TFT liquid crystal display device, a driving IC of the TFT liquid crystal display device and a flexible board FPC2 for a drain driving circuit of the TFT liquid crystal display device.

Brief Summary Text (3):
The present invention relates to liquid crystal display devices and, more particularly, to a liquid crystal display device including a flexible circuit which is provided along one of short sides of a liquid crystal display element formed by sandwiching a liquid crystal layer with a first substrate having active elements formed thereon and a second substrate having a common electrode formed thereon and which is connected at one end thereof to an interface circuit board to supply a driving signal voltage for display to said active elements and a driving IC chip which is mounted such that it connected to extraction lines of the active elements at output terminals thereof and to a conductive layer portion of said flexible board at input terminals thereof.

Brief Summary Text (16):
As described above, in a liquid crystal display element (liquid crystal panel) forming apart of a TN system active matrix type liquid crystal display device (hereinafter simply referred to as active matrix type liquid crystal display device for simplicity), there is formed a group of gate lines which extend in an x-direction in parallel with a y-direction and a group of drain lines which are insulated from the group of gate lines and which extend in the y-direction in parallel with the x-direction, on the surface toward a liquid crystal layer, of one of two transparent insulated substrates made of glass or the like provided in a face-to-face relationship with each other with the liquid crystal layer interposed therebetween.

Brief Summary Text (20):
However, since such a substrate is configured to allow TCPs carrying driving ICs to be externally mounted on the periphery thereof, the region between the contour of a display area formed by the regions where the group of gate lines and the group of drain lines cross on the substrate and the outer frame of the substrate (normally referred to as frame) occupies a large area, which goes against a need for reducing the external dimensions of a liquid crystal display module obtained by integrating a liquid crystal display element with an illuminating light source (back light) and other optical elements.

Brief Summary Text (21):
Therefore, in order to mitigate such a problem as much as possible, i.e., in consideration to a need for mounting liquid crystal display elements with high density and for reducing the external dimensions of liquid crystal display modules, the so-called flip-chip system or chip-on-glass (COG) system has been proposed in which image driving ICs and scan driving ICs are loaded directly on one of substrates (lower substrate) instead of using TCP components.

Brief Summary Text (24):
For example, a liquid crystal display device of this type is formed by laminating a

first substrate having on its periphery driving ICs for supplying driving signals to switching elements such as thin film transistors for driving pixels formed at intersections between a group of gate lines and a group of drain lines and a second substrate formed with a common electrode in a face-to-face relationship with each other, providing a liquid crystal display device by sandwiching a liquid crystal layer in the gap of the lamination, overlaying an illuminating light source for illuminating the liquid crystal display element, and securing them with an upper case and a lower case.

Brief Summary Text (25):
FIG. 43 is a schematic plan view of major parts for explaining the arrangement of a drain-driving IC for a liquid crystal display element and a drain-side flexible board forming a part of a conventional liquid crystal display device. SUB1 represents a first substrate (lower substrate) on which thin film transistors are formed; SUB2 represents a second substrate (upper substrate) on which color filters are formed; DTM represents drain extraction lines formed on the lower substrate; Td represents terminal wiring for connecting a protrusion (conductive layer portion) FSL of a drain-side flexible board FPC2 and a driving IC; COM represents a common electrode wiring for supplying power to a common electrode on the upper substrate SUB2; COMT represents a common electrode wiring terminal portion for electrically connecting the common electrode wiring COM to said common electrode through conductive paste or the like; ALC represents an alignment mark on the lower substrate SUB1; FHL represents a locating hole of the drain-side flexible board FPC2; AR represents a display area on a liquid crystal display panel; ARR represents a group of drain lines connected to one driving IC; CHD represents a chip capacitor for reducing noises on a power supply line of the flexible board FPC2; and a, b and c represent lines indicating the center of ARR, the center of the driving IC and the center of FSL, respectively.

Brief Summary Text (26):
Since the common electrode wiring COM for supplying power to the common electrode on the upper substrate SUB2 and the alignment mark ALC for defining the position of the liquid crystal display element during assembly are provided on the corner of the lower substrate which is furthest from an interface circuit board PCB of the liquid crystal display element, the driving IC and the conductor portion FSL, i.e., protrusion, of the flexible board FPC2 located in this region have been offset toward the interface circuit board PCB.

Brief Summary Text (27):
Specifically, as shown in FIG. 43, the center b of the driving IC in the direction parallel with the direction in which the extraction lines DTMP of active elements are arranged has been offset from the center a of the active elements driven by the driving IC in the direction in which the extraction lines DTM are arranged toward the interface board PCB (.theta..sub.1 <.theta..sub.2), and the center c of the protrusion FSL of the flexible board connected to the input terminals Td of the driving IC chip in the direction parallel with the direction in which the extraction lines DTM are arranged has been matched with the center b of the driving IC chip (.theta..sub.3 =.theta..sub.4).

Brief Summary Text (31):
It is an object of the present invention to solve the above-described problem and to improve the arrangement of extraction lines DTM of drain wiring, a driving IC for the same and a drain-side flexible board FPC2, thereby providing a liquid crystal display device in which the dimensions of the frame area can be reduced.

Brief Summary Text (32):
In order to achieve the above-described object, according to the present invention, a driving IC is mounted such that extraction lines DTM of drain wiring are inclined at angles to achieve symmetry about the center thereof (.theta..sub.1 =.theta..sub.2) and the angles of inclination of terminal wiring Td for connecting a protrusion (conductive layer portion) FSL of a flexible board FPC2 having a relatively low wiring density and the driving IC at both ends thereof are different from each other (.theta..sub.3 >.theta..sub.4). That is, the present invention is characterized in that it has a configuration as described below.

Brief Summary Text (33):
(1) There is provided a liquid crystal display element formed by sandwiching a liquid crystal layer with a first substrate having active elements formed thereon and a second substrate having a common electrode formed thereon, an interface circuit board provided along one of short sides of said liquid crystal display element, a flexible board connected to said interface circuit board at one end thereof and provided at least along one long side of said first substrate for supplying a driving signal voltage for display to said active elements and a driving IC chip mounted such that it is connected to extraction lines of said active elements at output terminals thereof and to a conductor layer portion of said flexible board at input terminals thereof.

Brief Summary Text (34):
The center of the extraction lines of said active elements driven by said one driving IC chip in the direction of the arrangement thereof is matched with the center of said driving IC chip in the direction parallel with the direction of the arrangement of the extraction lines of said active elements, and the center of the conductive layer portion of said flexible board connected to the input terminals of said one driving IC chip in the direction parallel with the direction of the arrangement of the extraction lines of said active elements is offset from the center of said driving IC chip toward said interface circuit board.

Brief Summary Text (36):
(2) Said one driving IC chip per (1) is mounted on said flexible board in the position furthest from said interface circuit board.

Brief Summary Text (37):
This configuration satisfies the need for offsetting the conductive layer portion of the flexible board toward the interface circuit board PCB in the region where the common electrode wiring COM and the lie are provided to increase the flexibility in designing the pattern of the lower substrate SUB1 in addition to the effect as mentioned in the above (1 1).

Drawing Description Text (2):
FIG. 1 is a schematic plan view of major parts of one embodiment of a liquid crystal display device according to the present invention to explain the arrangement of a drain driving IC and a drain-side flexible board thereof.

Drawing Description Text (5):
FIG. 4 is views of a liquid crystal display device (liquid crystal display module) which has been completely assembled and shows a front view thereof viewed from the front side of the liquid crystal display element PNL (that is, the side of the liquid crystal display element PNL) and a view of each side thereof.

Drawing Description Text (6):
FIG. 5 illustrates the rear side of the liquid crystal display module of FIG. 4 and an interface board mounted on a side thereof.

Drawing Description Text (7):
FIG. 6 is a plan view of major parts showing the arrangement of a gate-side flexible board FPC1 and a drain-side flexible board FPC2.

Drawing Description Text (9):
FIG. 8 is a view of the liquid crystal display module which has been completely assembled and shows a front view as viewed from the front side of the liquid crystal display element, a front side view, a right side view and a left side view.

Drawing Description Text (10):
FIG. 9 is a view of the liquid crystal display module which has been completely assembled and shows a rear view as viewed from the rear side of the liquid crystal display element.

Drawing Description Text (11):
FIG. 10 is a front view of a liquid crystal display element with driving circuit boards which is a liquid crystal display element having a gate-side flexible board

thermal expansion such that even the maximum shifts of the pitches P.sub.G and P.sub.D of the terminals TM are still in accordance with the length of the period of each driving IC. In this example of configuration, there is provided ten convex configurations divided in the longitudinal direction of the multi-layer flexible board, which allows the amount of thermal expansion to be reduced to about one-tenth, also contributes to relaxing application to the terminals TM and makes it possible to improve the reliability of the liquid crystal display module MDL against heat.

Detailed Description Text (73):
Chip capacitors CHG and CHD are mounted on the conductor layer portions FML of FPC1 and FPC2. Specifically, a chip capacitor CHG is soldered between the ground potential V.sub.ss (0 V) and the power supply V.sub.dg (10 V) or between the power supply V.sub.sg (5 V) and the power supply V.sub.dg on the gate-side multi-layer flexible board FPC1. Further, a chip capacitor CHD is soldered between the ground potential V.sub.SS and the power supply V.sub.dd (5 V or 3.3 V) or between the ground potential V.sub.SS and the power supply V.sub.dd on the multi-layer flexible board FPC2 on the drain side B. Those capacitors CHG and CHD are for reducing noises superimposed on the power supply lines.

Detailed Description Text (74):
This example of configuration is designed such that the above-described chip capacitor CHD is soldered only to the surface conductive layer L1 on one side and such that it is entirely located under the substrate SUB1 after the folding. It is therefore possible to mount the capacitors for smoothing power supply noises on the flexible boards FPC1 and FPC2 with the thickness of the liquid crystal display module MDL kept unchanged.

Detailed Description Text (76):
Since the shield case SHD is on the front side of the liquid crystal display module MDL and on the front side of the information processing apparatus, the generation of EMI (electromagnetic interference) noises at the surface thereof creates a significant problem in the environment in which external devices are used. For this reason, in this example of configuration, the surface layer L1 of the conductor portion FML is coated with the solid or meshed pattern ERH of a DC power supply as much as possible.

Detailed Description Text (81):
In this example of configuration, a multi-layer printed board made of a glass epoxy material is used as the interface circuit board PCB (hereinafter also simply referred to as board PCB). While a multi-layer flexible board can be also used, a multi-layer printed board which is relatively inexpensive is used because no folded structure is employed in this region.

Detailed Description Text (85):
In this configuration, a connector CT3 is used for electrical connection through electrical connection means JN1 between a flexible board FPC1 which is a gate driver board and the interface circuit board PCB.

Detailed Description Text (87):
As shown in FIG. 31, when viewed in the direction perpendicular to the substrates SUB1 and SUB2 forming a part of the liquid crystal display element PNL, the interface circuit board PCB is overlapped with the liquid crystal display element PNL and is provided under the lower side of SUB1. Further, the flexible board FPC1 for gate drivers is in direct electrical and mechanical connection to the substrate SUB1 of the liquid crystal display element PNL at one end thereof and is overlapped with the interface circuit board PCB throughout the width thereof without being folded unlike the drain-side thereof.

Detailed Description Text (92):
As shown in FIG. 33, a flexible board FPC2 for drain drivers is folded upon and bonded to the surface of the substrate SUB1 opposite to the surface formed with patterns. Polarizing plates POL1 and POL2 are provided slightly externally (about 1 mm) to an effective display area AR, and the end of FPC) is located at a distance of about 1 2 mm therefrom.

Detailed Description Text (94):
FIG. 27 is a perspective view for explaining a method for folding and mounting the multi-layer flexible boards. A flat connector CT4 as a joiner provided at the end of a convex portion JT2 constituted by a flexible board integral with FPC2 is used to connect the flexible board FPC2 for drain drivers and the flexible board FPC1 for gate drivers.

Detailed Description Text (108):
In the present example of configuration, the prism sheet PRS is constituted by two sheets which are placed on the spreading sheet SPS, and the prism sheets whose lower surface is a smooth surface and whose upper surface is a prism surface are disposed in an overlapping relationship such that their prism grooves are orthogonal. The prism sheets PRS converge light from the spreading sheet SPS toward the liquid crystal display element PNL to improve the luminance of the back light BL. This makes it possible to reduce the power consumption of the back light and to reduce the size and weight of the liquid crystal display module.

Detailed Description Text (111):
The convex portions MPN do not increase the thickness of the liquid crystal display module because they are in positions under the gate-side flexible board FPC1 which are not coplanar with the circuit board PCB.

Detailed Description Text (114):
This molded case MCA is tightly combined with the shield case SHD made of metal by actions of the fixing members and elastic body to improve the anti-vibration properties, anti-shock properties and hence the reliability of the liquid crystal display module MDL.

Detailed Description Text (115):
A large hole MO is formed on the bottom of the molded case MCA in a central region thereof excluding a frame-shaped region at the periphery, the hole occupying one-half or more of the area of said bottom. This prevents the bottom of the molded case MCA from being expanded by a force applied by the action of the rubber cushion GC between the back light BL and the molded case MCA to the bottom of the molded case MCA in the vertical direction from the upper surface to the lower surface thereof after the molded case NCA is assembled. This makes it possible to prevent any increase in the maximum thickness and to make the liquid crystal display module MDL thinner and lighter.

Detailed Description Text (118):
MH in FIG. 16 represents four mounting holes for mounting the liquid crystal display module MDL to an apparatus such as a personal computer as an application. The shield case SHD is also formed with mounting holes HLD matched with the mounting holes MH of the molded case MCA to be fixed and mounted to an apparatus as an application using screws or the like.

Detailed Description Text (127):
In FIGS. 1315, the cold-cathode fluorescent tube LP forming a part of the back light BL is provided along a long side of the liquid crystal display module MDL and under the display area. Specifically, as shown in FIGS. 41 and 42, the cold-cathode fluorescent tube LP is located under a long side of the display portion when mounted on an information processing apparatus such as a personal computer or word processor. In the example shown in FIGS. 13 and 14 in which an inverter IV is provided in an inverter containing portion MI in a display portion, the lamp cable LPC1 is provided along two sides, i.e., left and upper sides of the liquid crystal display module MDL, and the lamp cable LPC2 is provided along one side, i.e., the right side. In the example shown in FIG. 15 in which the inverter IV is provided in a keyboard, the, lamp cable LPC1 is provided along three sides, i.e., left, upper and right sides of the liquid crystal display module MDL, and both of the lamp cables LPC1 and LPC2 come out from a lower right portion.

Detailed Description Text (128):
By providing the cold-cathode fluorescent tube LP under the display portion of the liquid crystal display module MDL, even when the inverter IV is provided in the

keyboard portion as shown in FIG. 42, it is possible to reduce the length of the lamp cable LPC2 at the high voltage side of the cold-cathode fluorescent tube LP. This makes it possible to reduce impedance which can cause noises and changes in waveforms and to improve the activation characteristics of the cold-cathode fluorescent tube LP. When the inverter IV is provided at the keyboard, the width of the display portion can be further reduced. In addition, by providing the cold-cathode fluorescent tube LP under the display portion, reliability is improved because shock caused by opening or closing said display portion is mitigated. Furthermore, since the center of the display surface of the liquid crystal display element PNL is shifted upward, there is an advantage in that the view of a lower part of the display screen is not obscured by the hand of a user hitting the keyboard.

Detailed Description Text (131):
The drain driver portion 103 is mounted by folding the multi-layer flexible board described above. The interface board PCB having the controller portion 101 and power supply portion 102 mounted thereon is provided on the rear side of the gate driver portion 104 provided at the periphery on a short side of the liquid crystal display element PNL. The reason is that the limited horizontal width of the information processing apparatus required the width of the liquid crystal display module MDL forming a part of the display portion to be reduced as much as possible.

Detailed Description Text (135):
FIG. 39 is a block diagram showing a schematic configuration of each of drivers (drain drivers, gate drivers and common drivers) of the liquid crystal display element and the flow of signals. A display control element 201 and a buffer circuit 210 are provided in the controller portion 101 shown in FIG. 35; a drain driver 211 is provided in the drain driver portion 103 shown in FIG. 35; and a gate driver 206 is provided in the gate driver portion 104 in FIG. 35.

Detailed Description Text (138):
FIG. 39 illustrates the flow of display data and clock signals to the gate driver 206 and drain driver 211. FIG. 40 is a timing chart showing display data input from a main computer (host) to the display controller 201 and signals output from the display controller 201 to drain drivers and gate drivers.

Detailed Description Text (139):
The display controller 201 receives control signals from the main computer (a clock signal, a display timing signal and a synchronizing signal), generates a clock D1 (CL1), a shift clock D2 (CL2) and display data as control signals to the drain driver 211 and simultaneously generates a frame start indication signal FLM, a clock G (CL3) and display data as control signals to the gate driver 206.

Detailed Description Text (142):
<Information Processing Apparatus having Liquid Crystal Display Module MDL Mounted Thereon>

Detailed Description Text (143):
FIGS. 41 and 42 are perspective views of a notebook type personal computer or a word processor having the liquid crystal display module MDL mounted thereon. As previously described, FIG. 41 shows a case in which an inverter IV is provided in an inverter containing portion MI of the display portion, i.e., the liquid crystal display module MDL (see FIGS. 13 and 16) and FIG. 42 shows a case in which it is provided in a keyboard portion.

Detailed Description Text (144):
A signal from the information processing apparatus is first propagated from a connector located substantially in the center of an interface board PCB on the left-hand side to a display control integrated circuit element TCON to be converted into display data which in turn flows to peripheral circuits for drain drivers. Thus, by using the COG system and multi-layer flexible boards, the limitation placed on the horizontal width and outline of an information processing apparatus can be eliminated to provide a compact information processing apparatus having less power consumption.

Drawing Description Text (52):
FIG. 43 is a schematic plan view of major parts showing an arrangement of a drain driving IC and a drain-side flexible board of a liquid crystal display element forming a part of a conventional liquid crystal display device.

Detailed Description Text (3):
FIG. 1 is a schematic plan view of major parts of one embodiment of a liquid crystal display device according to the present invention for explaining an arrangement of a drain driving IC and a drain-side flexible board thereof. Similarly to the description on FIG. 43, SUB1 represents a lower substrate on which thin film transistors are formed; SUB2 represents an upper substrate on which color filters are formed; DTM represents drain extraction lines formed on the lower substrate; Td represents terminal wiring for connecting a protrusion (conductive layer portion) FSL of a drain-side flexible board FPC2 and a driving IC; COM represents common electrode wiring for supplying power to a common electrode on the upper substrate SUB2; COMT represents a common electrode wiring terminal portion for electrically connecting the common electrode wiring COM to said common electrode through conductive paste or the like; ALC represents an alignment mark on the lower substrate SUB1; FHL represents a locating hole of the drain-side flexible board FPC2; AR represents a display area on a liquid crystal display panel; ARR represents a group of drain lines connected to one driving IC; and a, b and c represent lines indicating the center of ARR, the center of the driving IC and the center of FSL respectively.

Detailed Description Text (5):
Meanwhile, the center c of the protrusion (conductive layer portion) FSL of the drain-side flexible board FPC2 is offset from the center b of the driving IC toward the interface circuit board PCB. This is an arrangement which is inevitably chosen because the formation of the wiring COM for supplying power to the common electrode and the alignment mark at a comer portion of the lower substrate SUB1 places a limit on the arrangement of said protrusion FSL toward the comer portion.

Detailed Description Text (6):
Therefore, the wiring Td at the protrusion FSL of the drain-side flexible board FPC2 is formed such that it has a steeper inclination at the side toward the interface circuit board PCB and a less steeper inclination at the opposite side (.theta..sub.3 >.theta..sub.4). However, since the wiring Td has a low wiring density and a large wiring width, the increase in resistance at the region thereof where the angle of inclination is .theta..sub.4 can be ignored.

Detailed Description Text (10):
In FIGS. 2 and 3, SHD represents an upper case (shield case); PNL represents a liquid crystal display element; SPC (SPC1 SPC2) represents an insulated spacer; SCP-P represents a protrusion of a spacer SPC (which is fitted into an opening formed on the upper case SHD); BAT represents a double-sided adhesive tape; FPC1, FPC2 represent multi-layer flexible boards (FPC1 represents a gate-side board and FPC2 represents a drain-side board); PCB represents an interface board; SPS represents a spreading sheet; PRS represents a prism sheet; GLB represents a light guide body; RFS represents a reflecting sheet; G represents a rubber cushion; MCA represents a lower case (molded frame); LP represents a cold-cathode fluorescent tube (CFL); LS represents a light source reflecting sheet; and LPCH represents a cable holder for the cold-cathode fluorescent tube.

Detailed Description Text (12):
A driving IC for driving gates is mounted on the edge of the lower substrate closer to the interface board PCB of the liquid crystal display element PNL, and a drive signal is supplied by the flexible board FCP1 to the driving IC for driving gates. A driving IC for driving drains is mounted on the side of the lower substrate adjacent to side where the interface board is provided, and a drive signal is supplied by the flexible board FCP2 to the driving IC for driving drains.

Detailed Description Text (13):
The liquid crystal display elements having the above-described driving ICs, flexible boards FCP1 and FCP2 and interface board PCB mounted thereon are hereinafter referred to as liquid crystal display element with peripheral circuits ASB.

Detailed Description Text (14):
The light guide body GLB is provided on the inner circumference of the lower case MCA with the rubber cushion GC interposed. The reflecting sheet RFS is formed on the rear surface of the light guide body GLB. The two prism sheets PRS (PRS1, PRS2) and the spreading sheet SPS are formed on the upper surface of the light guide body GLB; the liquid crystal display element with peripheral circuits ASB shown in FIG. 3 is placed thereon and is covered by the upper case SHD; and fixing nails NL formed on the periphery of the upper case SHD are engaged with the recesses for fixing formed on the lower case MCA to fix them together, thereby assembling the liquid crystal display device (also referred to as liquid crystal display module).

Detailed Description Text (16):
FIG. 4 is views of a liquid crystal display device (liquid crystal display module) which has been completely assembled and shows a front view thereof viewed from the front side of the liquid crystal display element PNL (that is, the side of the liquid crystal display element PNL) and a view of each side thereof. FIG. 5 illustrates the rear side of the liquid crystal display module in FIG. 4 and an interface board mounted on a side thereof.

Detailed Description Text (17):
A liquid crystal module MDL has two kinds of containing and holding members, i.e., a lower case (molded frame) MCA and an upper case (shield frame SHD). HLD represents four mounting holes provided for mounting said module MDL, as a display portion, to an information processing apparatus such as a personal computer, word processor or the like. The mounting holes HLD on the shield frame SHD are formed in positions corresponding to mounting holes MH (shown in FIG. 17 in an enlarged form) on the molded case MCA (FIGS. 4 and 8), and screws or the like are inserted through both mounting holes to secure and mount them to the information processing apparatus. An inverter for a back light is provided in a region MI (FIG. 8) of said module MDL, and power is supplied to the hack light BL through a connection connector LCT and a lamp cable LPC.

Detailed Description Text (18):
Signals from a main computer (host) and required power are supplied to a controller portion and a power supply portion of the liquid crystal display module MDL through an interface connector CT1 on an interface board located on the rear side of said module.

Detailed Description Text (19):
FIG. 5(b) illustrates an example of a configuration of the interface board PCB. Mounted on the interface board PCB are the connector CT1 for receiving signals from the main computer and required power, a low voltage differential reception circuit chip LVDS for converting a low voltage differential signal received from the main computer into an original parallel signal, a control circuit chip TCON, a digital-to-digital conversion circuit chip DD for generating various DC voltages, and connectors CT3, CT2 for connecting a gate-side flexible board FPC1 and a drain-side flexible board FPC2 to be described later.

Detailed Description Text (20):
FIG. 6 is a plan view of major parts for explaining the arrangement of the gate-side flexible board FPC1 and drain-side flexible board FPC2. A driving IC for driving gates is mounted on the upper surface of the interface board of the liquid crystal display element PNL, and the gate-side flexible board FPC1 is provided in connection to this driving IC. A driving IC for driving drains is mounted on the lower side of the liquid crystal display element PNL adjacent to the flexible board FPC1, and the flexible board FPC2 is provided in connection to this driving IC.

Detailed Description Text (21):
A protrusion JN4 is formed at the end of the flexible board FPC2 toward the gate-side flexible board FPC1, and a connector (flat connector) CT4 for connecting to the connector CT2 of the interface board PCB is provided at the end thereof. The flexible board FPC2 is folded on to the rear side of the liquid crystal display element PNL to connect said connector CT4 to the connector CT2 of the interface board.

Detailed Description Text (22):
In this embodiment, the connecting portion between the interface board PCB and the drain-side flexible board FPC2 is substantially flush with said flexible board FPC2. Therefore, there is no overlap of the drain-side flexible board FPC2 as described with reference to the prior art, which reduces the thickness of the liquid crystal display device as a whole in a corresponding amount to promote the trend toward smaller thicknesses.

Detailed Description Text (23):
FIG. 7 is an exploded perspective view for explaining a general configuration of another example of a liquid crystal display device according to the present invention. SHD represents an upper case (shield case); WD represents a display window (hereinafter also simply referred to as window); SPC (SPC1 SPC4) represents insulated spacers; FPC1, FPC2 represent folded multi-layer flexible circuit boards (FPC1 represents a gate-side circuit board and FPC2 represents a drain-side circuit board); PCB represents an interface circuit board; ASB represents an assembled liquid crystal display element with a driving circuit; PNL represents a liquid crystal display element formed by mounting driving ICs on one of two transparent insulated substrates in an overlapping relationship; PRS represents prism sheets (two sheets); SPS represents a spreading sheet; GLB represents a light guide body; RFS represents a reflecting sheet; MCA represents a lower case formed using integral molding (hereinafter also referred to as molded case); LP represents a linear light source (cold-cathode fluorescent tube); LPC1, LPC2 represent lamp cables; LCT represents a connection connector for an inverter; and GB represents a rubber bush for supporting the cold-cathode fluorescent tube. They are stacked in the illustrated vertical relationship of arrangement and fixed by the upper case SHD and lower case MCA to be assembled into a liquid crystal display device (liquid crystal display module) MDL. Further details of the configuration will be described below.

Detailed Description Text (24):
FIG. 8 is a view of the liquid crystal display module which has been completely assembled and shows a front view as viewed from the front side (i.e., from the upper side or display side) of the liquid crystal display element PNL, a front side view, a right side view and a left side view.

Detailed Description Text (25):
FIG. 9 is a view of the liquid crystal display module which has been completely assembled and shows a rear view as viewed from the rear side (i.e., the bottom side) of the liquid crystal display element PNL.

Detailed Description Text (26):
The liquid crystal display module MDL has two kinds of containing and holding members, i.e., the molded case MCA and the shield case SHD. HLD represents four mounting holes provided for mounting said module MDL, as a display portion, to an information processing apparatus such as a personal computer, word processor or the like. The mounting holes HLD on the shield case SHD are formed in positions corresponding to mounting holes MH (FIGS. 16 and 17 to be described later) on the molded case MCA (see FIG. 7), and screws or the like are inserted through both mounting holes to secure and mount them to the information processing apparatus. An inverter for a back light is provided in a region MI of said module MDL, and power is supplied to the back light BL through the connection connector LCT and the lamp cables LPC.

Detailed Description Text (27):
Signals from a main computer (host) and required power are supplied to a controller portion and a power supply portion of the liquid crystal display module MDL through an interface connector CT1 located on the rear side of said module.

Detailed Description Text (28):
FIG. 35 is a block diagram showing the TFT liquid crystal display element of the liquid crystal display module shown in FIG. 2 and the circuits provided around the same. Although not shown, in the present embodiment, drain drivers IC.sub.I IC.sub.M are mounted on a chip-on-glass basis (COG mounting) together with drain-side extraction lines DTM and gate-side extraction lines GTM formed on one of the

substrates of the liquid crystal display device using an anisotropic conductive film or ultraviolet hardening resin.

Detailed Description Text (36):
CSP represents through holes for setting the relative positions of the shield case SHD and other components accurately by mounting the shield case SHD such that fixedly erected pins are inserted in the through holes CSP during manufacture. The insulated spacers SPC1 SPC4 are insulators applied with adhesive on the surface thereof, and the shield case SHD and liquid crystal display device with driving circuits ABS can be reliably secured at an interval maintained by the insulated spacers. When said module MDL is mounted on a product such as a personal computer as an application, the through holes CSP can be a reference to positioning.

Detailed Description Text (39):
<Multi-Layer Flexible Board FPC1, FPC2>

Detailed Description Text (40):
FIG. 10 is a front view of a liquid crystal display element with driving circuit boards which is a liquid crystal display element PNL having a gate-side flexible board FPC1 and an unfolded drain-side flexible board FPC2 mounted on the periphery thereof.

Detailed Description Text (42):
FIG. 12 is a rear view showing a state in which the flexible board FPC2 has been folded to contain the liquid crystal display element PNL in a shield case SHD after mounting the flexible boards FPC1, FPC2 and the interface circuit board PCB with the shield case SHD placed thereunder.

Detailed Description Text (46):
The driving ICs are mounted such that the center thereof coincides with the center a of the drain lines driven by said driving ICs in a display area AR, as illustrated in FIG. 1, and the center c of a conductor layer portion (protrusion) FSL of the drain-side flexible board FPC2 for connecting to terminal wiring Td of said driving ICs is offset from the center b of the driving ICs toward the interface circuit board PCB.

Detailed Description Text (47):
In a system in which drain lines or gate lines are alternatively extracted, although the drain lines DTM or gate lines GTM can be easily connected to bumps BUMP at the output side of driving ICs, peripheral circuit boards must be provided at the periphery on the two opposite long sides of the liquid crystal display element PNL. This results in a problem in that the external dimensions become greater than those in the case of extraction at only one side. Especially, when the number of displayed colors is increased, the external dimensions of an information processing apparatus become large because of an increase in the number of data lines. In the present example of configuration, therefore, a multi-layer flexible board is used to extract drain lines at only one side.

Detailed Description Text (48):
FIG. 20 is an illustration of a multi-layer flexible board FPC2 for driving drain drivers; (a) is a rear (bottom) view; and (b) is a front (plane) view. FIG. 22 is an illustration of a multi-layer flexible board FPC1 for driving gate drivers; (a) is a rear (bottom) view; and (b) is a front (plan) view.

Detailed Description Text (49):
FIG. 26 illustrates a structure of the multi-layer flexible board FPC2 shown in FIG. 20; (a) is a sectional view taken along the line A--A in FIG. 20(a); (b) is a sectional view taken along the line B--B in the same; and (c) is a sectional view taken along the line C--C in the same. For the purpose of description, the ratio between the dimensions in the direction of thickness and the direction of the plane of FIG. 26 is different from that of actual dimensions and is shown in an exaggerated form.

Detailed Description Text (50):
FIG. 23 is a wiring diagram showing signal wiring in the multi-layer flexible board

FPC and connection of an input signal to a driving IC on the substrate SUB1. The signal wiring in the multi-layer flexible board FPC consists of a first group of lines in parallel with one side of the substrate SUB1 and a second group of lines perpendicular thereto. The first group of lines is a group of common lines for supplying a signal common to driving ICs, and the second group of lines is a group of lines for supplying a signal required for each of the driving ICs. Therefore, the portion FSL is formed by at least one conductive layer. The portion FML is formed by at least two conductive layers, and the first group of lines and the second group of lines must be electrically connected by a through hole. In this example of configuration, the length of the short sides of the portion FML must be reduced to a length such that it does not touch the lower polarizing sheet when folded.

Detailed Description Text (55):
The multi-layer flexible board is advantageous in that the conductive layer L5 including the connection terminal portion TM required for COG-mounting can be configured integrally with the other conductive layers to reduce the number of components.

Detailed Description Text (56):
In addition, the portion FML can be a rigid portion having less deformation when it is formed by three or more conductive layers and, as a result, a locating hole FHL can be provided in this portion. No deformation occurs in this portion when the multi-layer flexible board is bent, which allows the board to be bent with high reliability and accuracy. Furthermore, as described later, a solid or meshed conductor pattern ERH having a multiplicity of small holes ESH with a diameter of, for example, about 200 Mm (see FIG. 28(a)) can be provided on the surface layer L1, and conductor patterns for mounting components and for peripheral wiring can be provided on two or more of the remaining conductive layers.

Detailed Description Text (58):
By forming the protrusion FSL with two or less conductive layers, it is possible to achieve high thermal conduction during thermal pressure bonding using a heat seal and to allow the application of a uniform pressure, thereby improving the reliability of electrical connection between the connection terminal portion TM and the terminal wiring Td. Further, the multi-layer flexible board can be bent with high accuracy without applying a bending stress to the connection terminal portion TM. In addition, since the protrusion FSL is semitransparent, patterns on the conductive layers can be seen from the upper surface of the multi-layer flexible board, which is advantageous in that pattern inspections such as on the state of connection can be carried out from the upper surface. JT2 in FIG. 20 represents a recess for electrically connecting the drain-side flexible board FPC2 and the interface circuit board PCB, and CT4 represents a flat type connector provided at the end of the convex portion JT for electrically connecting the flexible board FPC2 and the interface circuit board PCB.

Detailed Description Text (59):
FIG. 21 illustrates major parts of the multi-layer flexible board FPC2; (a) is an enlarged detailed view of the portion J in FIGS. 20(a); and (b) is a side view showing the mounting and folding of the multi-layer flexible FPC2.

Detailed Description Text (60):
In FIG. 21(a), P.sub.X represents the wavelength of an wavy configuration at an end of the polyimide film BFI; P.sub.Y represents the height of the wave (the amplitude of the wave .times.2); P.sub.1 represents a straight line connecting peaks of the wave (referred to as peak line of the wave); and P.sub.2 represents a straight line connecting bottoms of the wave (referred to as bottom line of the wave). LY2 represents the length of the connecting portion between the multi-layer flexible board FPC2 and the substrate SUB1 (referred to as connection length), and LY1 represents the length between the connecting portion between the multi-layer flexible board FPC2 and substrate SUB1 and the peak line P.sub.1 of the wave.

Detailed Description Text (61):
As shown in FIG. 21(b), the drain-side flexible board FPC2 is connected to the terminals of the drain lines (terminals Td in FIGS. 24 and 25) at the end of the SUB1 of the liquid crystal display element PNL at one end thereof through the

anisotropic conductive film ACF and is folded at an intermediate portion of the wave height P.sub.Y outside the edge thereof. The multi-layer wiring portion FML at the other end is disposed on the lower side of SUB1 and is applied to the lower side of SUB1 with the double-sided adhesive tape BAT. The numbers 145 assigned to the output terminals TM in FIG. 16(b) correspond to the numbers 145 assigned to the terminals Td in FIGS. 24 and 25. They are electrically connected through an anisotropic conductive film ACF1.

Detailed Description Text (62):
As described above, according to this configuration, in the flexible board FPC2 for signal input connected to the end of the substrate SUB1 of the liquid crystal display element at one end thereof and folded upon the lower side (or upper side) of said substrate SUB1 at the other end thereof, the end of the polyimide film BFI of the protrusion FSL thereof is molded in a wavy configuration (or a configuration having peaks and bottoms such as a comb-like configuration) along the direction of a folding line. This makes it possible to disperse a concentration of stress at the end of the polyimide film BFI in the folded region, to provide the folded region with a preferable curve (R) and to prevent the occurrence of wire breakage, thereby improving reliability.

Detailed Description Text (63):
In this example of configuration, the gate-side multi-layer flexible board FPC1 has three conductive layers, i.e., L1 for V.sub.dg (10 V), V.sub.sg (5 V) and V.sub.ss (ground), L2 for extraction lines, a clock CL3, FLM and V.sub.dg (10 V), for V.sub.EG (-10 to 7 V), V.sub.EE (-14 V), V.sub.SG (5 V) and a common voltage V.sub.com.

Detailed Description Text (64):
A description will now be made on alignment marks ALMG (FIG. 22(a)) and ALMD (FIG. 21(a)) on the multi-layer flexible board.

Detailed Description Text (65):
In the multi-layer flexible boards FPC1 and FPC2 shown in FIGS. 2022, the length of the output terminals TM is normally designed at about 2 mm in order to maintain reliability of connection. However, since the long sides of the flexible boards FPC1 and FPC2 are long, a positional shift including a slight rotation in the direction of the long axis can cause a positional shift between the input terminal wiring Td and output terminals TM, which can lead to poor connection. The alignment between the liquid crystal display element PNL and the flexible boards FPC1 and FPC2 is carried out by aligning the input terminal wiring Td and output terminals TM in several points after inserting the fixed pins into the holes FHL formed on both sides of each board. Two each alignment marks ALMG and ALMD are provided at each protrusion FSL in order to improve accuracy further.

Detailed Description Text (67):
The common voltage is supplied to the common transparent pixel electrode on the substrate SUB2 through the pattern COM of the terminal wiring Td on the substrate SUB1 via conductive beads or paste.

Detailed Description Text (68):
The alignment marks ALMG are provided such that they are connected to the terminal COMT electrically connected to the common transparent pixel electrode COM through patterns and are aligned with square solid patterns ALD on the substrate SUB1 (see FIG. 25). Further, in this example of configuration, there is provided a joint pattern (not shown) for connecting to the flexible board FPC1 for the gate drivers at the lower end of the flexible board FPC2 for the drain drivers in FIG. 20(a).

Detailed Description Text (70):
The protruding configuration FSL formed by one or two layers of conductor wiring is separated into a convex configuration for each driving IC. Therefore, the multi-layer flexible boards thermally expand in the direction of the longer axes thereof during thermal pressure bonding using a heat tool. This causes changes in pitches P.sub.G and P.sub.D of the terminals TM to prevent it from coming off the connection terminals Td or to prevent poor connection. Specifically, the separate convex configuration for each driving IC makes it possible to provide an amount of

Detailed Description Text (151):
FIG. 37 illustrates the flow of display data and clock signals to the gate driver 104 and drain driver 103. As previously described, the display controller 101 receives control signals from the main computer (a clock signal, a display timing signal and a synchronizing signal), generates a clock D1 (CL1), a shift clock D2 (CL2) and display data as control signals to the drain driver 103 and simultaneously generates a frame start indication signal FLM, a clock G (CL3) and display data as control signals to the gate driver 104.

CLAIMS:

1. A liquid crystal display device comprising:

a generally rectangular liquid crystal display panel formed by sandwiching a liquid crystal layer between a first substrate having active elements formed thereon and a second substrate having a common electrode formed thereon;

an interface circuit board provided along one of the short sides of said liquid crystal display panel;

a flexible board connected to said interface circuit board at one end thereof and provided at least along one long side of said first substrate for supplying a driving signal voltage for display to said active elements;

and a driving IC chip mounted such that it is connected to extraction lines of said active elements at output terminals thereof and to a conductor layer portion of said flexible board at input terminals thereof; wherein

the center of the extraction lines of said active elements driven by said driving IC chip in the direction of the arrangement thereof is matched with the center of said driving IC chip in the direction parallel with the direction of the arrangement of the extraction lines of said active elements, and the center of the conductive layer portion of said flexible board connected to the input terminals of said driving IC chip in the direction parallel with the direction of the arrangement of the extraction lines of said active elements is offset from the center of said driving IC chip toward said interface circuit board.

2. A liquid crystal display device according to claim 1, characterized in that said driving IC chip is mounted on said flexible board at a position furthest from said interface circuit board.

5. A liquid crystal display device comprising:

a first substrate having a matrix of drain signal lines and gate signal lines, and a plurality of thin film transistors, each provided at respective intersections between two adjoining drain signal lines and two adjoining gate signal lines, a drain electrode and a gate electrode of each thin film transistor being connected to a drain signal line and a gate signal line, respectively, and a source electrode of said thin film transistor is connected to a pixel electrode;

a second substrate having a common electrode formed thereon;

a liquid crystal layer provided between said pixel electrode and said common electrode;

an interface circuit board provided along first sides of said first substrate which having a plurality of gate terminals connected to said gate signal lines;

a flexible board connected to said interface circuit board at one end thereof and provided at least along a second side of said first substrate for supplying a driving signal voltage for display to said drain signal lines;

and a driving IC chip mounted such that it is connected to extraction lines of said drain signal lines at output terminals thereof and to a conductor layer portion of said flexible board at input terminals thereof; wherein

and an unfolded drain-side flexible board mounted on the periphery thereof.

Drawing Description Text (13):
FIG. 12 is a rear view showing a state in which the flexible board has been folded to contain the liquid crystal display element in a shield SHD case after mounting the flexible boards and the interface circuit board with the shield case SHD placed thereunder.

Drawing Description Text (21):
FIG. 20a is a front view of a multi-layer flexible board FPC2 for driving drain drivers.

Drawing Description Text (22):
FIG. 20b is a rear view of the multi-layer flexible board FPC2 for driving drain drivers.

Drawing Description Text (23):
FIG. 21a is an enlarged view of a region J of the multi-layer flexible board PC2 shown in FIG. 20a.

Drawing Description Text (24):
FIG. 21b is a side view of the multi-layer flexible board PC2 in a state in which it is connected to a lower substrate SUB1 of a liquid crystal display panel.

Drawing Description Text (25):
FIG. 22a is a front view of a multi-layer flexible board for driving gate drivers.

Drawing Description Text (26):
FIG. 22b is a rear view of the multi-layer flexible board for driving gate drivers.

Drawing Description Text (27):
FIG. 23 is a wiring diagram showing signal wiring in a multi-layer flexible board and connection of an input signal to a driving IC on a lower substrate.

Drawing Description Text (33):
FIG. 27 is a perspective view sowing a method for folding and mounting a multi-layer flexible board and showing a portion thereof connected to another multi-layer flexible board.

Drawing Description Text (45):
FIG. 36 is a block diagram showing an equivalent circuit of the liquid crystal display module.

Drawing Description Text (46):
FIG. 37 illustrates the flow of display data and a clock signal to gate drivers and drain drivers.

Drawing Description Text (48):
FIG. 39 is a block diagram showing a schematic configuration of each of drivers (drain drivers, gate drivers and common drivers) of the liquid crystal display element and the flow of signals.

Drawing Description Text (49):
FIG. 40 is a timing chart showing display data input from a main computer (host) to a display controller and signals output from the display controller to drain drivers and gate drivers.

Drawing Description Text (50):
FIG. 41 is a perspective view of a notebook type personal computer or word processor in which a liquid crystal display module is mounted.

Drawing Description Text (51):
FIG. 42 is a perspective view of another notebook type personal computer or word processor in which a liquid crystal display module is mounted.

a center of the extraction lines of said drain signal lines driven by said driving IC chip in the direction of the arrangement thereof is matched with the center of said driving IC chip in the direction parallel with the direction of the arrangement of the extraction lines of said drain signal lines, and the center of the conductive layer portion of said flexible board connected to the input terminals of said driving IC chip in the direction parallel with the direction of the arrangement of the extraction lines of said drain signal lines is offset from the center of said driving IC chip toward said interface circuit board.